REPORT

OF THE

DIRECTORS OF INTERNAL IMPROVEMENT

ON THE SUBJECT OF

RAIL ROADS.

TRANSMITTED TO THE LEGISLATURE

JANUARY SESSION, 1830.

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Commonwealth of Massachusetts.

In Senate, Jan. 14th, 1830.

Ordered—

That fourteen hundred copies of the Report of th Directors of Internal Improvement, be printed for th use of the General Court.

Attest, PAUL WILLARD, *Clerk.*

Commonwealth of Massachusetts.

To the Honorable the Senate, and the Honorable the House of Representatives.

The Directors of Internal Improvement have the honor, herewith, respectfully to submit such further information upon the construction and utility of Rail Roads as they have been enabled to obtain, in compliance with a concurrent order of the two Houses of the Legislature, at the last session. Considering the duty assigned them, by the terms of their Commission, as merely ministerial, in collecting and presenting facts applicable to the "practicability and expediency" of adopting this particular species of improvement, they feel constrained to confine themselves to a communication of the result of such examinations as they have directed, and of the practical operations which have fallen within the scope of their inquiry, as evidence to others, rather than to offer observations, which are the effect of the additional information thus acquired, upon their own minds. They will not forbear, however, to add an expression of satisfaction, that all their previous anticipations of the

value of such Improvements are abundantly confirmed, and that they feel an assured confidence in the correctness of the calculations and estimates of the expense of their construction, as well as the inducements to, and promise of advantage from their enjoyment, which in a former Report, they so fully and unequivocally expressed.

It was deemed expedient to ascertain, in the first place, how far the face of the country, and the manner of executing the work of constructing Rail Roads, in other places, would, upon comparison, afford encouragement to similar undertakings in Massachusetts. The Directors, therefore, sought to avail themselves of the experience which other States had already acquired on this subject. It was known that Pennsylvania had engaged extensively in similar enterprizes, after the best means had been resorted to, for direction in her plans of public improvement. The People and State of Maryland, also, had undertaken one of the greatest enterprizes of the age, in the Baltimore and Ohio Rail Road, upon the most careful investigation of the principles and character of this mode of intercommunication, and upon critical inquiries into its practical operation upon the business and interests of Society. Scientific men had been sent to Europe, expressly charged to obtain all the information, which the introduction and use of Rail Roads there, could afford, and the result had been, a decision, in both of the aforementioned States, in favor of their equal applicability to the circumstances and occasions of Transportation, in our own Country. With a view to the knowledge, which might be obtained, by an examination of the works which were thus in progress, and from a direct communication with those who had their superintendence, a Committee, composed of one of the

Members of the Board, and the Engineer, who had been employed in the Survey of the Providence Route, and whose intelligence and accuracy were fully approved, were authorized to visit the scenes of those improvements, and to make the inquiries, and procure all the information which could be found useful, in the proceedings which were to be had here. In the course of the season, this Committee accordingly examined the principal public works in the States of Pennsylvania and Maryland, and have made a Report of the result of their observations, which the Directors herewith transmit, and request may be received, as part of the execution of their Commission.

It will be seen, that the State of Pennsylvania is deeply committed to the objects of Internal Improvement. The extent to which she is at this time engaged, in Canals and Railways, either on the public account or in joint stock associations of her Citizens, exceeds *Twelve hundred miles*, at an estimated cost of *Fifteen Millions of Dollars*. The Committee found no degree of discouragement entertained, on account of the magnitude of these undertakings, or from any obstacles which had been presented to their accomplishment. On the other hand, they met every where, on the routes of their location, the strongest manifestation of the improvement of country, by the progress of the works, and received assurances of the entire dependence of the interests of trade, manufactures and agriculture, upon their successful completion.

In the description of the Baltimore and Ohio Rail Road, an explanation is afforded of the great expense of its construction. The most extraordinary difficulties are there overcome, and excessive sacrifices made, to

conform to a preferred location of the Road, in reference to its approach to the City of Baltimore. High embankments, deep cuttings, magnificent Bridges and Viaducts of solid masonry, faced and ornamented with hammered granite brought from great distances, are the occasions of cost, which are not usually within the estimates of such improvements, and exclude all comparison between that work and others, which, anywhere else, have been projected. Yet is the enterprize still prosecuted with a zeal and confidence of success, which admits no distrust, on this account, of the attainment of the ultimate object. The considerations of encouragement, which the promised advantages from its use have presented, are strikingly applicable to the circumstances of our own State, in relation to an improved communication, between the Capital and the trade of the North River.

On the route of this Road, the Rails have been laid for nearly two miles from the City, upon which experiments of the most satisfactory character have been recently made, in the rapid passage of Carriages, moved by Horse power. The Way is graded, and prepared to receive the Rails for nearly twenty three miles further, and great progress has been made upon other sections of the route. The estimated cost of the whole work exceeds, *more than two fold*, that of all the improvements taken together, which have been proposed in Massachusetts. The State is, at the same time, engaged in another Rail Road from Baltimore to the River Susquehanna, the first stone of which was laid in August last, and upon which much labour has already been done. Besides all this, the mighty project of the Chesapeake and Ohio Canal is in a state of vigorous prosecution.

Through the instrumentality of an application, by the President of this Board to His Excellency Governor Martin of Maryland, the Directors were put in possession of much more minute information, on the subject of the public works in that State. Among the Documents herewith transmitted to the Legislature will be found an original communication from Colonel Long of the United States Topographical Engineers, and President of the Board of Engineers employed on the Baltimore and Ohio Rail Road, containing precise answers to definite inquiries, which were proposed in relation to the progress of that principal work, and also on the general subject of this kind of construction, the best application of moving power in its improvement, and the preference to be given to it, over other modes of conveyance. This valuable Document was expressly prepared for the instruction of this Government, and entitles the distinguished Officer, who promptly and gratuitously furnished it, to very grateful acknowledgments. In the authentic character of the information which it contains, where we have the known results of the application of scientific principles to the laws of matter, and of practical experience in the operations of labour, the Directors are spared the occasion of repeating their own observations upon the same subjects of inquiry, which were presented to their attention. It will well supply the place of opinions and suggestions, which less particular information obtained elsewhere, would otherwise have required them to make, and must be received as an acceptable substitute for any detail by themselves, in regard to whatever it embraces.

From a comparison of the description which is given of all the works, both in Pennsylvania and Maryland,

with the Surveys which have been had here, it cannot fail to be seen, that we have few of the difficulties to overcome, which are found in those States. The Country here is less broken into deep and precipitous inequalities of surface, the elevation is no where so great for a like distance of way, upon any proposed route for a Road, the earth is of a kind more easy of removal and graduation, and materials are both more abundant and better suited to the construction of the tracks. The courses of location, also, are in the general, more direct. It would seem too, from the information furnished us, that the work, even there, may be constructed at a rate, having regard to the character of the ground, as low as the estimates which have been made with us. Iron for the Rails has actually been obtained, at less cost, and some contracts for excavating and removing earth and preparing the way for the Rails, have recently been entered into, at a price below the allowance in the estimates of our own Engineers. These latter circumstances are particularly deserving of note, as fortifying the reliance which may be placed upon the sufficiency of former calculations for similar works, in this Commonwealth.

In the prosecution of the inquiries to which our attention has been directed, we have been called to receive, in astonishment, the accounts which are given, of recent experiments in England, upon the capacity and adaptation of Steam Carriages, as a self-moving power over Rail Roads. This invention promises to produce a new era in the business and arrangements of Society. The effects which are to result from it can hardly be compassed by the anticipations of the most sanguine. Distance is lost in the application of this power to the pur-

poses of conveyance. A rate of travelling, with a velocity of from 20 to 30 miles the hour, is fully demonstrated to be within the capacity of these Engines, and the ease, safety, and economy of this mode of dispatch are made equally apparent. Thus will Intercourse of every description be facilitated. Places of market, heretofore considered too remote from each other for intercommunication, will be rendered easily accessible. The labour bestowed upon transportation, will be spared to the purposes of production; and that diffusion of wealth which is the fruit of trade, extended through City and country, from the mart of commerce to the field of the Husbandman's culture, and through the Workshops of the Mechanic and Manufacturer, will be richly experienced. Whenever the time shall arrive for the introduction of these machines into the United States, the inexhaustible beds of coal which have been discovered, will supply abundant fuel for Engines, while the ways over which these move, will render the facility and cheapness of that supply, the strongest inducement to their use. Yielding entire confidence to the accounts of the experiments to which we have referred, we deem it proper to offer to the Legislature, as part of the information which may be expected from this Report, various extracts from periodical publications in Europe, to show how greatly the advantages, heretofore proposed from Railways, are increased in prospect, by recent discoveries.

The Directors are not aware, in conclusion, that there is any thing more for them to add to the Report of their Committee, which, in connexion with the communication of Colonel Long, the extracts before referred to, together with the foregoing remarks, will present all the

information of which they are possessed, upon the subjects of inquiry proposed by the order of the Legislature, and in compliance with which the same is humbly submitted.

LEVI LINCOLN,
NATHAN HALE,
DAVID HENSHAW,
GEORGE BOND,
THOMAS W. WARD,
WILLIAM FOSTER,
ROYAL MAKEPEACE.

Boston, January 12th, 1830.

REPORT

Of Edward H. Robbins, *and* James Hayward, Esqrs., *who were appointed to visit the Works of Internal Improvement in the States of Pennsylvania and Maryland.*

To the Board of Directors of Internal Improvement.

Boston, December 15, 1829.

Gentlemen,—

Having, in pursuance of your request, visited the States of Pennsylvania and Maryland, for the purpose of examining the public works and other internal improvements in these States, to collect facts which should throw light upon the question of adopting a system of inter-communication by rail-roads, now before the Legislature of this state,—we Report the following facts :—

We first visited the Delaware and Hudson Canal and Rail-road, constructed for the purpose of conveying coal from the Lackawannock valley, near the North branch of the Susquehanna River, to the Hudson River. This Canal commences near Kingston on Hudson river, 90 miles from the city of New York, and runs in a south-westerly direction to Delaware river, near the northern extremity of New-Jersey ; up the Delaware to the mouth of the Lackawaxen river, and thence along the Lackawaxen to its head waters in Honesdale in Wayne county, Pennsylvania

The whole length of this canal from the Hudson to Honesdale, is 108 miles. The average cost per mile is about $18,000. The Delaware division cost $20,000 per mile. This great expense of construction was occasioned by the exceeding roughness of the country through which it is carried, the large amount of rock excavation, and the great extent of river wall and other stone work along the banks of the Delaware, Lackawaxen, and Neversink rivers, as well as the great amount of lockage in proportion to the length of the canal; there being 1088 feet in the 108 miles.

Another circumstance which enhanced very much the expense of construction, is, that a considerable portion of this work was undertaken in an entire wilderness, where provisions and other accommodations for the laborers were obtained at great inconvenience and cost; and where all transportation of materials for the various structures, was done under the greatest disadvantages. From the terminus of this canal in Honesdale, a railroad 16 miles in length connects it with a coal bed in Carbondale on Lackawannock creek, a tributary to the Susquehanna River, in the county of Luzerne. The general level of the coal bed is nearly the same with that of the canal basin in Honesdale; but the intermediate country (Lackawannock Mountain) rises 800 feet above this level. This rise of 800 feet from the coal bed is surmounted in the first 3½ miles, upon the railroad, by five inclined planes of from 2,000 to 3,000 feet each, with short intermediate levels. The loaded cars are drawn up these planes by stationary steam engines, by an endless chain passing round pullies at the head and foot of the plane, while the empty cars being attached to the opposite part of the chain, descend by a side

track parallel to the main way. The inclination of these planes is from 1 in 20 to 1 in 12.

From the summit towards Honesdale, there is a descent of 6 feet in the first 1¾ miles. From this place the cars descend, by stationary conducting apparatus, three planes, (of 4260 feet, 1560 feet, and 910 feet,) inclined to the horizon in an angle of 1 to 12, with intermediate planes of such inclinations as will admit of the cars descending by gravity, with no other regulation of their speed than what may be given by the application, by their conductors, of a break to the circumference of the wheel.

Up these easy inclinations the empty cars are drawn by horses ; there being a *side-track* about mid-way, in each of them, where the trains of waggons moving in opposite directions, pass each other. One of these planes is nearly 6 miles in length ; they have an inclination of from 27 to 44 feet in a mile. We passed up one of these planes of between 3 and 4 miles in length, in a train of 4 waggons and 12 men, with some other luggage, drawn by a small horse of very ordinary appearance, which did not break his trot for the whole distance. The waggons weigh a net ton each; and the other part of the load drawn by this animal, may be fairly estimated at another ton ; making in all *five tons.*

The inclinations in these long planes are greater than it is proposed to admit in the projected rail-way from Boston to Providence ; and even as great as will be necessary, except in a few instances and those for short distances, in the route surveyed by Mr. Baldwin to Connecticut river. This, however, was considered no trial of the animal's power ; the train being one, which, in the ordinary course of their business, happened to be

passing at the time at which we wished to pass up the road.

This rail-road consists of a single pair of tracks of wooden rails, six inches by ten, with an iron plate rail, 2½ inches by ½ an inch, screwed upon them, and supported by cross sleepers at intervals of about ten feet.

This structure, it will be perceived, is very similar to the rail-road at Quincy, except that the iron rails, instead of being supported by an oak scantling, are fastened directly to the main rail which is of hemlock, a wood perhaps less suitable for this purpose than the hard pine of this part of the country. Where the road crosses ravines or hollows, the track is supported by upright timbers from the ground, to which the sleepers are framed.

It may be proper here to remark that the place above-mentioned, which we ascended in a train weighing 5 tons, is designed for the use of a small locomotive engine: but, the road not being entirely ready for the locomotive, a temporary horse path has been constructed of the neighbouring earth, (except where the road is raised some distance above the surface,) in which case, the horse path is of plank. This earth is of a clayey character; and, owing to the recent rains, was at the time we visited it, extremely muddy. It is manifest, that with a good gravelled or macadamized path, the horse would carry a far greater load with the same ease. It is also a well-ascertained fact, that a horse will draw a much greater load upon a rail-way of granite than upon one of wood.

The stationary conductors upon the three planes descending towards Honesdale, are what are called pneumatic convoys, an apparatus by which the inertia of the

atmosphere is made use of to prevent a too great velocity of the descending car.

At first, such a system of inclined planes with stationary apparatus, seemed formidable: But the dexterity with which they are managed, notwithstanding the short time in which they have been in operation; the facility and dispatch which they give in surmounting great elevations; and their simplicity and cheapness, are strong arguments in favour of adopting them where abrupt acclivities are to be passed. It has been ascertained that more than 400 tons per day can be passed through this system of planes.

The stationary engines of thirty-horse power cost $3000, each, and require but one man to each to manage them. One of these engines consumes about a ton of coal per day, which costs, delivered at the engine, not more than 40 cents. The rail-way, independent of the apparatus for passing the inclined planes, cost $6,500 per mile.

This canal and Rail-road were constructed solely for the purpose of transporting the anthracite coal found in the vicinity of Carbondale, to the Hudson River; yet a great deal of incidental trade has already sprung up along the line, although the canal has been but a short time in operation; unforeseen advantages are beginning to be realized, by the agricultural interest, for many miles on each side. It has given the farmers a ready cash market and high prices for every kind of produce which they have to sell, while it has diminished, *one half*, the cost of such heavy articles as they are obliged to transport from mercantile towns. Industry and enterprize are thus promoted and rewarded; the value of real estate is greatly enhanced; and towns and villages

are already springing up, where, were it not for this canal, the comforts of life could hardly be obtained by the most untiring industry. And we have been elsewhere struck with the evident operation of the same principle, which we have no doubt will be found to be general. Throughout those parts of the country along which we travelled, the evidences of enterprize, comfort, thrift, and intelligence seemed nearly in proportion to the facilities of inter-communication.

The coal of Carbondale is somewhat lighter than the Mauch Chunk or Lehigh coal; it ignites more readily, and burns with greater freedom. Coal of the same character shows itself at intervals along the Lackawannock creek and through the Wyoming valley to Wapwallopen creek, an extent of 60 or 70 miles. It is probably but one *formation;* and, where it has been examined, has been found to be from 20 to 25 feet thick. It is probably several miles in width.

From Carbondale we passed down the Lackawannock, and thence down the Susquehanna River to York-Haven. At Pittston, at the mouth of the Lackawannock, we came upon the route of what is called the *Middle Division* of the Pennsylvania Canal.

It may be proper to state that the *Pennsylvania Canal* consists of five divisions, viz: *The Transverse Division* commences at Columbia in Lancaster county, on the east bank of the Susquehanna River, extends along this river to the mouth of the Juniata, and thence up the Juniata, and down the Kiskiminitas and Allegany rivers to Pittsburg. The whole length of this line of communication from Columbia to Pittsburg is 322 miles; the general direction is west-northwest; the Allegany mountain between the Juniata and Kiskiminitas, is to be passed by a rail-road about 40 miles in length.

The *Middle Division* extends from the mouth of the Juniata up the Susquehanna to the junction of the North and West branches of this river at Northumberland, and thence up the North Branch of the Susquehanna to the boundary line between Pennsylvania and New-York. The length of this division is 204 miles.

The *West Branch Division* commences at Northumberland, about 40 miles above the mouth of the Juniata, and extends up the west branch of the Susquehanna 70 miles to Dunnstown. Beyond this place the canal has not yet been located.

The *Eastern Division* is in the valley of the Delaware River, commencing at Bristol, 18 miles above Philadelphia, and terminating at Easton, where it unites with the Lehigh Canal, which is owned by the proprietors of the coal mine at Mauch Chunk. From Bristol to Easton is 60 miles.

The *Western Division* is to extend from the mouth of the Kiskiminitas up the Allegany River and French Creek, and thence to the town of Erie, on Lake Erie. Only twenty miles of this division are yet completed. Great progress has been made, however, towards the entire completion of the other divisions of this important work.

As a part of the great system of internal improvement undertaken by this enterprising State, is the *Columbia Rail-Road*, which passes from Philadelphia, through the counties of Chester and Lancaster, to Columbia, the commencement of the *First Division* of the State Canal. The length of this rail-road is 80 miles.

Besides these *Public Works*, there are, within the state of Pennsylvania, belonging to joint stock companies, canals and rail-roads, whose aggregate length

amounts to 475 miles; which, added to the state works above described, gives 1231 miles of canals and rail-roads within the state of Pennsylvania.

The entire cost of these state works will probably amount to 15 millions of dollars. This expense, however, is readily incurred by those who represent the agricultural interests of the Commonwealth, with the feeling of certainty that these will be amply remunerated in the various sources of gain which this system of inter-communication will open into the interior of the state; in the facilities which it will give for the exchange of their domestic products for necessary and useful articles of the growth and manufacture of other states; in the encouragement which will be given to domestic enterprize and domestic industry; and in the comfort, improvement, and happiness, which will thus be promoted throughout the Commonwealth.

The inhabitants of the great valley of the Susquehanna, which is in fact a large portion of the state, would find a natural outlet for their produce through the mouth of the Susquehanna River, to Baltimore; but knowing the advantages of having a choice in the markets, and the means of dispatch in transportation, they are now constructing, for the purpose of securing these advantages, the "Pennsylvania Rail-Road," to connect the main trunk of their State Canal with the city of Philadelphia; notwithstanding that there is, between these places, a communication somewhat less direct, by the Union Canal, through the Swatara and Schuylkill rivers.

We travelled for about a week in those parts of the country where these works are just going into operation; we conversed with the people, and had an opportunity of witnessing the incipient influence of these improvements

upon their feelings, and the prospects of the country. They spoke of the advantages which had already been realized from having so much money expended in the interior of the country; of the incidental business about to grow out of this system of improvement, independent of the increased value it gives to the general products of the country, and the corresponding diminution of the cost of those articles which are brought from the sea-board. But the most striking illustration of the advantages to be derived from these increased facilities of inter-communication, is its effect upon the value of real estate. Capitalists from Baltimore, New York, and Philadelphia, have come into the country and bought large tracts of land for twice and even three times the price which the owners would have been glad to receive for it were it not for the canals and rail-roads.

Leaving the Susquehanna river at York-Haven, we next visited Baltimore for the purpose of witnessing the progress of the Baltimore and Ohio Rail-Road, and collecting facts respecting the facilities which the country affords for such a work, and the manner and cost of its construction.

Of this road we found but two or three miles actually completed; though it is nearly ready to receive the rails for a distance of 25 miles: And it is expected that the road will be completed for this distance, early in the ensuing summer.

The bad weather, and the great depth of the mud, occasioned by excessive rains, and the clayey nature of the formations through which the road is constructing, prevented us from following the line of the road, and extending, as far as we had intended, our examination of the facilities which the face of the country, together

with its geological features, affords for a work of this kind. This circumstance, however, was of less importance, as the politeness of the Gentlemen having charge of the work, furnished us with plans and profiles of the ground, and communicated every kind of information with so much particularity as to leave us nothing to desire in this respect.

This rail-road, which is to open a communication between the city of Baltimore and the Ohio River, will be about 350 miles in length. From Baltimore it passes in a southerly direction, seven miles, into the valley of the Patapsco river; then along the valley of the west branch of this river to Parr Spring Ridge, which separates the waters of the Patapsco from those of the Monocacy river. Thence its general direction is southwesterly across the Monocacy valley, crossing the Monocacy river in the vicinity of Pinkneytown, and meeting the Potomack river at a place called the *Point of Rocks*, at the foot of the Catoctin Mountain. The rectilinear distance from Baltimore to the Point of Rocks is 50 miles; the distance by the rail-road is 70 miles.

The course of this road, it will be perceived, is somewhat more circuitous than those of the Massachusetts rail-roads. The distance in a straight line from Boston to Springfield is 82 miles: the length of the proposed rail-road between these two places is only 95 miles. The rectilinear distance between the proposed *termini* for the Boston and Providence rail-road, is 39 miles 72 chains; the distance by the proposed road is 43 miles 48 chains.

The route of the Baltimore and Ohio road, at the Parr Spring Ridge, at the distance of 23 miles from Baltimore, attains an elevation of 836 feet, a height

more than 300 feet greater than that of the Worcester summit on the Boston and Hudson rail-road, and nearly equal to the highest summit between Boston and Connecticut river. From the Parr Spring Ridge eastward, there is a fall of 500 feet in the first fifteen miles; a greater difference of level than is to be found in the same distance on the proposed rail-roads in Massachusetts, east of Connecticut river. From the Parr Spring Ridge westward, the descent is 600 feet in the first 15 miles.

The route of the rail-road between Baltimore and the Patapsco river, lies across deep ravines, and elevations of such extent, as to require great expense in excavation and embankment. We observed, in a short distance from the commencement of the road, one embankment of one-fourth of a mile in length, and 57 feet greatest depth; and another of half a mile in length, and varying from 12 to 17 feet in height. At the distance of about three miles from the city, there is a cut of three-fourths of a mile in length, and 70 feet greatest depth. There are other extensive embankments between this point and the Patapsco river; and along the valley of that river, in that part of the road now nearly prepared for the reception of the rails, it has been necessary to cut through extensive beds of limestone and hard granite. In one instance, the road is carried through a solid rock, the top of which is 58 feet higher than the surface of the road.

We mention these facts to show the difficulties which the conductors of this work have had to encounter, and the enterprize required to overcome them; and also to justify what seemed to us, before we knew these facts, an extravagant estimate of the expense of constructing these divisions of the road. But a comparison of the

work actually done on this portion of the road, with that which would be required in preparing the surface of the rail-roads which have been proposed in Massachusetts, will show that the published estimates of expense for the first 25 miles of the Baltimore and Ohio road, are low in comparison with the estimates made for the Boston and Providence, and the Boston and Hudson Rail-Roads. The excavation and embankment in the first *seven miles* of the road from Baltimore to the Patapsco valley, amounted to 1,284,197 cubic yards. The excavation and embankment required in the first *forty miles* of the proposed road from Boston towards the Hudson, as given in Mr. Baldwin's estimates, amounts to 1,279,544 cubic yards. The whole amount of excavation and embankment required in forming the ground for a double rail-road from Boston to Providence, is 984,856 cubic yards.

These considerations afford a full explanation of the great expense of the Baltimore road, in comparison with the estimates which have been given of the probable cost of the rail-roads proposed in Massachusetts.

Another circumstance, which goes to show that these estimates for the Massachusetts Rail roads are sufficiently high, is, that the cost of those portions of the Delaware and Hudson Canal and Rail-Way, and of the Pennsylvania Canal, which may be fairly compared with analogous work proposed to be undertaken in Massachusetts, has not, so far as we could learn, exceeded these estimates. Excavation of earth and stone of various kinds, embankment and stone work, where the facilities in the two cases seemed to be equal, have been actually accomplished, and the iron for the rails obtained, within the prices estimated for the same work in Massachu-

setts. And now, after so fair a trial of the actual cost of this kind of work, the conductors of the Pennsylvania Rail-Road have recently placed 40 miles of that work under contract, at prices less than those which were allowed for the same kind of work, in the estimates made for the Boston and Providence Road.

The actual expense of constructing the Baltimore and Ohio Road, thus far, has greatly exceeded the first estimates for this part of the work. The explanation of this excess of the actual cost, over the estimated expense, is that the original estimates were for wooden bridges over the several streams which are intersected by this part of the road, for which the board of direction subsequently determined to substitute permanent stone masonry.

The bridges are built in a manner which for durability and elegance is probably unequalled in the United States. The bridge over Gwynn's Falls is 300 feet in length and 50 feet in height from the bed of the stream to the road-way. It consists of two arches, one of 80 feet chord and one of 20 feet. The smaller arch is over a road upon the bank of the river. The structure is of hewn granite; it contains over *eleven thousand* perches of stone masonry, which cost, on an average, *six dollars* per perch.

Ten miles from Baltimore the road crosses the Patapsco river by a stone bridge of four arches; the two interior arches are each 55 feet chord, and the two exterior ones are each 20 feet chord. The length of this bridge is 375 feet, the height is 45 feet. There are in the first two divisions of the road, that is in the first 25 miles, many smaller bridges, of stone arches of from 10 to 25 feet chord. We did not see the bridge over the

Patapsco, nor any of the bridges in the Patapsco valley; but we understand that they are all executed in the same workmanlike manner. We are informed that in these 25 miles there are *fifty-six thousand* perches of stone masonry, all of this permanent kind.

Another circumstance which added to the cost of this part of the road, was the sudden and uncommon advance in the price of labour which took place about the time this work was commenced. The neighbouring state of Pennsylvania had, at this time, large portions of her canal under contract; which not only gave full employment to her own labourers, but called to her aid such as could be conveniently spared from the ordinary operations of husbandry in the neighbouring states. The Chesapeake and Ohio canal was commenced simultaneously with this rail-road, in its immediate vicinity, and in part upon its very site. These works, from being rivals in their general object, became rivals in their progress. The call for laborers was beyond the immediate supply; and contracts were made, and work done, at prices much above the ordinary standard of wages. And the same call for dispatch continued the operations during the winter and rainy seasons, in which the same amount of labour is much less effective than during the other seasons of the year.

Although the expense of constructing this division of the road, has, in the aggregate, so far exceeded the original estimate, there are portions of this work which have fallen short of the estimated cost. The conductors of the work are, from these experiments, able to speak with greater confidence respecting the remainder of the line; and they express their entire belief that, notwithstanding the change of plan from that of wooden

bridges to permanent stone work; and the great expense incurred in this part of the road, the work may still be completed from Baltimore to the Ohio, at an expense certainly not greater than the original estimate of $20,000 per mile.

The stockholders have the most entire confidence in the success of the enterprize; and the public in general seem fully aware of the immense advantages which this system of transportation for the interiour is about to open to the various sections of our country. The citizens of Baltimore exhibit such a fixed conviction of the success and importance of the enterprize in which they have embarked, and such a determined spirit in its prosecution, that, notwithstanding the magnitude of their undertaking, depending chiefly on individual enterprize and capital, no reasonable doubt exists of their accomplishing the grand end, of establishing an easy, economical, and rapid inter-communication with the Ohio river. The practical use of their rail-road, and its advantages to the trade of that city and to the country into which it is to open a communication, are so little the subject of doubt, that the installments amounting to twenty-five per cent of the whole capital, have been promptly paid, and in many instances the assessments have been anticipated. The effect on property is already perceptible; sales of estate are oftener effected without diminished prices; and both in the city and country new accommodations and facilities for business are in preparation, which have reference entirely to the accomplishment of this important work.

We had much conversation with one of the engineers employed by the Baltimore and Ohio Company to visit the rail-roads in Europe. The accounts which these

gentlemen give of the operations which they witnessed, are of the most satisfactory nature. And we confess that the experiments which are now making in those states which we have just visited, both as it respects the works themselves and the effects which they are producing in those parts of the country through which they pass, have very much strengthened our own confidence in the ultimate success, and in the great importance to the people of our own state, of that system of transportation for the interior, which has been proposed for Massachusetts.

The recent experiments which have been made in England upon rail-roads and rail-road carriages, have put beyond question the vast superiority of this method of transportation over that by canals, independent of the climate and the face of the country: And we are fully persuaded that no part of the United States, and perhaps no part of the world, possesses greater facilities, on the whole, for this species of inter-communication than the state of Massachusetts. And we feel a confident hope that, while other states are enlarging their resources and increasing their wealth and their means of general improvement, our own state may not be left to fall into premature decay, but enabled to participate in the growing prosperity of our country.

Respectfully your obedient servants,

E. H. ROBBINS, Jr.
JAMES HAYWARD.

COMMUNICATION

Of Col. Long, *President of the Board of Engineers of the Baltimore and Ohio Rail Road Company, made at the request of the President of that Company, in reply to certain inquiries addressed to the latter by the President of the Board of Directors.*

Dear Sir,

The letter of his Excellency Levi Lincoln, Governor of the State of Massachusetts, which you have done me the honor to put into my hands, and to request an exposition of my views in reference to the several topics therein proposed, claims my most respectful consideration not only on account of the importance of its subject but of the source whence it emanates, and the channel through which it comes.

Any information in my power to communicate, shall be cheerfully given, with the hope on my part, that its deficiencies, will be compensated for, by details far more interesting and useful, from your own pen.

The subjects in relation to which his Excellency has requested information, are the following, viz:—

1st. The progress already made in the Baltimore and Ohio Rail Road.

2nd. The manner in which the work is constructing.

3rd. Cost of grading the Way.

4th. Materials for the side tracks.

5th. Difference in expense between double and single tracks.

6th. Relative advantages and convenient use of the one and the other.

7th. Best and cheapest application of powers whether Stationary, Locomotive or Animal.

A brief discussion of these topics will be attempted in the order just given.

1*st. Of the Progress already made in the Baltimore and Ohio Rail Road.*

A definitive location of the Rail Road has been made through a distance of nearly 70 miles, commencing within the city of Baltimore and terminating at a place on the margin of the Potomac river denominated the Upper Point of Rocks. The principles that govern in the location with respect to the horizontal position of the road, are, that its direction shall be as straight as the nature of the surface will admit, consistently with the greatest economy ; and that where curvatures are unavoidable the minimum radius of curvature allowable upon the main line, is 400 feet. To this general rule, three exceptions only have as yet been deemed advisable, viz. two in the valley of the Patapsco, in reference to one of which a radius of about 318 feet, and to the other, a radius of 210 feet has been admitted. The third exception has taken place in the valley of Bush Creek, in reference to which a radius of about 280 feet, has been admitted.

With respect to ascents and descents, the system that has been adapted is predicated on the probable relative amounts of tonnage or freights in opposite directions upon the road, which have been assumed in the propor-

tion of 1 ton Westward, or from Baltimore, to 5 tons Eastward, or to Baltimore. The graduation corresponding to such a state of trade is a declivity of about 13 feet per mile in the direction of the greater tonnage. Accordingly, in the location of the road, an ascent of 13 feet per mile westward, has been regarded as preferable to a level. Moreover, it has been pretty satisfactorily ascertained, that a horse travelling at the rate of 4 miles per hour, can draw but half as much as when his speed is 2 miles per hour, which is equally true also with respect to other rates of speed. The ordinary working gaits of a horse being a *walk*, and a *trot*, and the speed of the latter being about double that of the former, a computation was made in order to determine the acclivity, up which a horse moving at a walk, could draw the same load with which he could move in a trot, upon a level road. On comparing the result thus found with the inclination before mentioned as equivalent to a level, the conclusion was drawn, that the appropriate load for a trotting horse on an acclivity of 13 feet per mile, could be drawn with equal facility by the same horse walking, up an acclivity of about 30 feet per mile: —and by a parity of reasoning, the appropriate load for a trotting horse on a declivity of 13 feet per mile, could be drawn with equal facility by a walking horse on a dead level.

In conformity to these views, and for the purpose of accommodating the surface of the road to the natural surface of the ground, in order to save expense in its construction, it was determined that any rate of ascent, proceeding westward from a level to 30 feet per mile, should be regarded as a *level* in contradistinction to *Inclined Planes*—that wherever the ascent westward should

exceed the rate just mentioned, the acclivity should be regarded as an Inclined Plane ; and that any ascent eastward should be regarded as an Inclined Plane,—upon which an increased power in some due proportion must be provided for. The rate at which provision should be made for transportation upward on Inclined Planes, so far as I am able to judge from the various experiments bearing upon this subject, is exhibited in the following arithmetical proportion, viz: 26.4, 52.8, 79.2, 105.6, 132, 158.4, 184.8, 211.2, 237.6, 264,—these several expressions indicating the acclivity in feet per mile, at which 2, 3, 4, &c. horses can ascend with the load of one horse on a level.

The inclination indicated by the last expression, viz. 264 feet, is nearly three degrees, which is regarded as the maximum declivity advisable in the construction of a Rail Road ;—the reason of which is, that in the worst state of the road, and weather, frost and snow excepted, that is, when the rails are covered with dust saturated with moisture, the adhesion of the wheels to the rails is so much impaired, as to endanger their slipping on a greater declivity. In consequence, the trouble and expense of stationary brakes must be encountered, in order to regulate the descent of carriages, whereas on a declivity less than three degrees, their descent may be regulated by brakes or convoys attached to the carriages.

The work of construction has been hitherto confined to that portion of the road situated between the city of Baltimore, and the Forks of the Patapsco, embracing a distance of about 25 miles. Commencing at Baltimore, the first seven miles of this distance extend across numerous spurs, ridges and ravines, which have given occasion to a corresponding number of deep excavations,

high embankments, and expensive stone bridges. The magnitude and cost of the work on this part of the road may be inferred from the following facts, viz : that the amount of excavation has exceeded 66,000 cubic yards, that of Embankment 630,000 cubic yards, and that of Masonry 25,000 Perches. The cuttings, for the most part, have been made in an adhesive indurated clay,—and the stone required for the masonry has been procured at the distance of many miles from the work. The cost of preparing the bed of the road on this distance only, has already amounted to more than $400,000, or about $58,000 per mile. The amount of excavation at the Deep Cut, three miles from Baltimore, is no less than 312,000 cubic yards, and its cost about $112,000. The high embankment nearly 7 miles from Baltimore, contains about 276,000 cubic yards, and its cost inclusive of two stone Bridges will have been not less than that of the Deep Cut. The residue of the first Division of the Road extending to Ellicott's Mills about 6½ miles farther, is benched for the most part upon the abrupt river hills, cliffs and precipices of the Patapsco ; yet notwithstanding the rugged nature of its locality, is far less difficult and expensive, than the portion just before considered. Stone suitable for the construction of bridges was here far more convenient,—and it has been found that the trouble and expense of grading even upon the rocky sides of hills and precipices were far less than those attendant upon cutting through ridges, and embanking across valleys. The aggregate cost of grading and bridging on this part of the road, has been about $250,-000, or $38,500 per mile.

On the second Division of the Rail Road which extends from Ellicott's Mills along the immediate valley

of the Patapsco, to the confluence of the North and South Forks of that stream, a distance of about 11½ miles, the facilities for construction become obviously greater, and the actual cost of grading and bridging has been proportionally less. The bridges and culverts on this Division are completed, and about three fifths of the grading has already been accomplished. The aggregate cost of these items, on the second Division will have been about $118,450, or $10,300 per mile.

It is expected that the formation of the Road-bed on a distance of about 10 miles next above the second Division will prove equally as expensive as that of the Division just mentioned, but that the grading and bridging on the residue of the distance (33 miles) to the Potomac river at the Point of Rocks. will not cost more than $231,000, or $7000 per mile.

The passage of Parr Spring Ridge, dividing between the waters of the Patapsco, and those that fall into the Monocacy, is proposed to be effected by means of stationary machinery at the summit of the Ridge, and an inclined plane on each side of the summit. The inclination of these planes will probably be about 2½ degrees, and their length respectively about one mile. These are the only planes on which it is contemplated, at present, to employ stationary power. The residue of the distance from the summit just mentioned to the Monocacy, (12 miles) is nevertheless to be regarded as one continued plane, upon which carriages will descend spontaneously, but will require in their ascent about three times the power ordinarily required on other parts of the road for return transportation ; a similar declivity of about two miles in extent, occurs on entering the immediate valley of the Potomac, in reference to which a

similar arrangement is contemplated, viz. an application of increased power for the return transportation.

2d. *Of the manner in which the work is constructing.*

The width to be occupied on account of the road, agreeably to charter, is 66 feet, of which 26 feet is occupied by the graded surface of the rail-road, together with such additional width as may be necessary to the requisite side slopes in *cuttings* and *fillings*. The entire surface of the ground upon which the road bed, inclusive of its embankments, rests, is cleared and divested of all perishable materials, such as logs, stumps, brush, &c. In valleys and depressions, embankments with side slopes of $1\frac{1}{2}$ to 1, or about 33°, are raised to the grade line of the road; while the ridges and other prominences, occurring upon the route, are cut through to the same level, or grade line, leaving a surface width of 26 feet, and slopes upon the sides in the proportion of 1 to 1, or 45°. Wherever the line of the road is intersected by water courses, a free passage is provided for the water by means of stone bridges, culverts, or transverse drains, the minimum size of the last of which, is such as to admit the entrance of a man for the purpose of clearing them when choked with sand or otherwise. The masonry hitherto done, has been executed not only in a substantial, but in an ornamental manner. Almost the whole of it has been embellished with dressings and facings, which have contributed to render it much more costly than it otherwise would have been. It is proposed in future to substitute rubble work, instead of that of a higher finish, which it is believed will prove equally

as durable and efficient, at a cost far less than that hitherto encountered.

Of the surface width of the road above mentioned,(viz. 26 feet) 20 feet are to be occupied by a stone covering thereon 4 inches thick, composed of fragments reduced to such size as will admit of their being passed respectively through a ring 2 or $2\frac{1}{2}$ inches in diameter. The residue of the width, viz. 3 feet on each side of the stone pavement, is to be occupied by side drains, which are deemed necessary to the effectual drainage of the road.

The railing proposed for the road is of two kinds, viz. of wood and of stone, surmounted by bars of wrought iron about 15 feet long, $2\frac{1}{4}$ inches wide, and $\frac{5}{8}$ inch thick, appropriately rounded on their upper sides and perforated with elliptical holes about 15 inches asunder. The wooden railing has hitherto been adopted, with a view, 1st, to its cheapness, 2nd, to the facilities it will afford for the transportation of the more heavy materials required for a more permanent road, and 3d, to the state of the embankments which cannot be regarded as sufficiently stable for the permanent support of stone rails, till they shall have been allowed four or five years for their settling and consolidation. The method of applying the wooden rails is as follows.—Sleepers of locusts or cedar about 8 feet long and 7 inches in diameter at the smaller end, have been procured at an expense of about 35 cents each, delivered upon the road. These sleepers are notched for the reception of the wooden rails or string pieces, and appropriately dressed, at an additional expense of about 8 cents each. They are then laid in trenches dug transversely of the rail track at the distance of 4 feet from centre to centre,

and supported at each end upon a bed of rubble stone 18 inches long, 12 inches wide, and 12 inches deep. The rails which are of Southern-heart pine six inches square, and in lengths from 15 to 40 feet (cost, delivered at Baltimore, 6 cents per foot, running measure) are then laid in the notches of the sleepers, adjusted with precision, both to the grade, and centre lines of the road, (which lines are carefully designated by bench marks, and stakes, indicating the true flexures of the road) and confined in the notches by means of keys (12 inches long, 2 inches wide, $1\frac{1}{2}$ inches thick at the but, and $\frac{3}{4}$ inch thick at the point) driven upon the inner side of the wooden rails. The distance from out to out of the notches, and consequently of the wooden rails, is precisely 5 feet. The iron rails are next applied to the string pieces, and are confined to their upper surfaces, by means of pressed or wrought iron nails, four inches long and $\frac{3}{8}$ inch square (cost 9 cents per pound.) The iron rails are scarfed at their extremities at an angle of about 60 degrees with the side of the rail, and at their junction rest on an iron plate about 4 inches long, and $\frac{3}{16}$ inch thick, perforated in coincidence with the nail holes in the ends of the rails. The nail holes are furnished with an ellipsaidal countersink, in the upper side of the rail, into which the head of the nail, which is of a corresponding form, is driven, entirely below the upper surface of the rail. The elliptical form of the countersinks, and nail holes, has been adopted with the view of accommodating the expansion and construction of the iron rails, and thereby obviating the inconvenience that must otherwise result from the drawing or breaking of the nails. The aggregate expansion of an iron bar, computed for the extremes of atmospheric tempera-

ture in this climate, is estimated at about $\frac{1}{4}$ of an inch in a bar 15 feet long. Hence at a mean temperature, viz. about 45 degrees, as at present we are in the habit of allowing, a space of about $\frac{1}{8}$ of an inch between the ends of the rails. The rails, &c. being thus adjusted, the next step is the placing of broken stone, reduced to fragments of a size to pass through a six inch ring, on the inside of both string pieces, and in contact with them, 9 inches in width, and about 4 inches in depth, leaving a space for the horse tread $2\frac{1}{2}$ feet wide between the two ranges of stone just adverted to. This space is then filled with earth to a level with the upper surfaces of the sleepers, and broken stone reduced to fragments that will pass through a 2 inch ring, is laid to the depth of about 3 inches upon the surface thus prepared, forming a substantial pavement for the horse-tread. The coarse rubble stone at the sides of the horse path afford the means of draining the latter, the water passing off through the interstices between the stones, and beneath the rails.

The iron rails have been imported from England. Their cost, inclusive of freight, difference of exchange, drayage, &c. is $58 per ton.

The contemplated method of laying stone rails, is similar to that adopted on the Quincy Rail-way, except in so far as relates to their foundations, and the manner of their insertion into the pavement, which are as follows.—A trench will be sunk through the stone covering first mentioned below the reach of frost, for the reception of the stone rail which is to rest upon coarse rubble stone placed in the bottom of the trench, and embracing the rail-stone on both sides, within the trench.—An additional quantity of finely broken stone will then be laid to

the depth of about 3 inches between the rails in a manner to form the horse paths, and to fill the space intervening between the two tracks.—The drainage of the road will be effected by means of water courses slightly depressed in the pavement and leading transversely across both tracks, at suitable intervals from each other. These water-courses may be rendered continuous entirely across the Rail-way, by means of spaces sufficiently large for that purpose, left occasionally between the ends of the rail-stones.

3rd. Of the Cost of Grading the Way.

Several of the items in reference to this subject have already been anticipated under our first head. It may here be added that the cost per cubic yard for excavation and embankment (that which is in excess on any section of the road being alone estimated) has varied from 12½ to nearly 50 cents, according to the hardness and tenacity of the earth, and the distance to which it must be transported. Excavations in granite rock, where blasting has been required, have cost from 50 to 87½ cents per cubic yard. In many instances, the excavated materials have been transported to the distance of half a mile. In ordinary cases it is believed that the cost of grading has been doubled, when the distance to which the materials must be conveyed, was ¼ of a mile, and tripled when the distance was ½ a mile.

4th. Of materials for the Side Tracks.

The materials of which the sidelings or Bolting tracks are constructed are similar to those employed for the

main tracks, except that the Branch Rails connecting the sidelings with the main tracks ought always to be of cast iron. No doubt exists however, of the propriety of constructing wooden sidelings, plated with iron, in connection even with stone railing, inasmuch as neither the failure of a sideling nor its consequent repairs need occasion any serious obstruction to the business done on the main way. The divergence of a sideling should always be equal to the distance between the main tracks of a double Rail-way. The angle of divergence adopted on the Baltimore and Ohio Rail Road, is about 6 degrees. The line of divergence, is not a right line, but two segments of a circle constituting a reversed curve.

5th. Of the difference in expense between a Double and Single track.

The difference in the cost of a Double and Single Rail-way, is much less than is generally supposed. The graded surface required for the latter, can only be reduced in width, a distance equal to that intervening between the centres of the tracks of the former. For example, the Baltimore and Ohio Rail Road is to be furnished with two tracks, and has a graded surface 26 feet wide. The distance from centre to centre of the tracks is $8\frac{1}{2}$ feet, this distance deducted from 26 feet leaves $17\frac{1}{2}$ feet for the graded surface adapted to a single Rail-way, more than $\frac{2}{3}$ the width required for a double one. The cost of grading and bridging may be fairly estimated nearly in the same proportion. Moreover, the rails of one track having been laid, the facilities for laying those of the other are greatly augmented. The rails, stone, and other materials required for its

construction can be conveyed at so much less expense, to the sites where they are wanted, that at a fair estimate, the saving in expense will be nearly or quite equal to $\frac{1}{5}$ the cost of the 1st track. Another consideration of much moment, is also to be had in reference to this subject. The sidelings or bolting tracks upon a single Rail-way, must be much more numerous, and extensive than on a Double, inasmuch as in connexion with the latter they serve merely as resting or stopping places, whereas in connexion with the former they must serve as receptacles for all the cars travelling in either direction.

It should nevertheless be regarded as a safe conclusion, that wherever a single track is sufficient to subserve the purposes of travel and transportation, between any two points, it is unquestionably preferable to a double one, and that in all cases, a single track should first be constructed, and subsequently a double one, whenever the exigencies of the business done upon the road should require the addition. In accordance with these views, it would be advisable to prepare a road bed for a single railway, wide enough for the admission of two tracks, inasmuch as the cost of grading would not be greatly enhanced thereby, while at the same time a firm and substantial foundation would be prepared for the future reception of a second track.

6th. *Of the relative Advantages and Convenient Use of a Single and Double Railway.*

Among the advantages of a double railway, are the facilities for an uninterrupted progress in both directions, for the accommodation of travel and transportation, at

different rates of speed, and for an almost incalculable amount of business that may be done upon the road. The facilities afforded by a single railway are far less in all these respects. The sidelings upon the former are not only to be regarded as resting places, but as affording opportunities for rapid cars, laden with passengers, to pass and run before the more sluggish vehicles laden with merchandize, both maintaining an unremitted progress. The sidelings of the single railway serve merely as meeting places, upon which a train of carriages may be delayed for a considerable time, waiting the arrival of another train, bound in the opposite direction; nor do they afford any opportunity for carriages, bound in the same direction, to pass each other, except when they chance to be unoccupied by waiting carriages. On a double railway, the times of departure, as well as the rates of speed, are at the option of the traveller. On a single railway, he must conform to stated periods and movements, not only at the commencement, but through the entire progress of his journey. On a double railway, the travel may be incessantly in both directions, and in case a rapid or despatch car overtakes a train moving at a more moderate pace, the latter should be required to turn out at the next sideling, and leave the main way clear for the former to take the lead.

The foregoing remarks are applicable more particularly to railways intended for reciprocal trade and intercourse between distant points. The colourings by which these two species of roads are to be distinguished become fainter, as their extent diminishes, till at length the more favourable colouring must be given to the single railway. A single railway has subserved the purposes of commerce between Stockton and Darlington,

8 miles asunder, whereas the Liverpool and Manchester railway, 36 miles long, has been furnished with two tracks.

It has been thought that the business likely to be done on the Baltimore and Ohio Rail-Road, embracing an extent of 350 miles, would require two tracks, while the Boston and Providence Rail-Road, extending through a distance of a little more than 40 miles, might not require more than a single track, with frequent sidelings.

7th. *Of the Best and Cheapest application of Powers, whether Stationary, Locomotive or Animal.*

The means hitherto employed for locomotion, as connected with a reciprocal commerce upon rail-roads, are of two descriptions only, viz. Steam power and Animal power, that of gravitation having been found applicable only in a descending trade, connected exclusively with mining operations. Other agents, such as water, in overcoming ascents, and gas, produced from spirits of turpentine and water, may hereafter be employed to advantage, but as yet no conclusive demonstrations of their utility or efficiency have been given. We shall accordingly confine our remarks to the agents first mentioned, viz. steam power and horse power.

The preference to be given to either of these, so far as they are connected with the subject before us, must depend in a great measure upon the speed with which it is proposed to move upon a rail-road, and upon the facilities of procuring fuel suitable for the generation of steam, and convenient for use in a locomotive engine.

With a speed not exceeding two and a half miles per hour, there is little doubt that horse power in most parts

of the United States, even within the regions of bituminous coal, would prove quite as economical, as Steam power for the purpose of locomotion upon a horizontal Rail Road. And could this description of power be applied, through the intervention of Stationary Machinery, or by any other means to the production of a greater speed, without increasing that of the moving power itself, its efficiency might still be regarded as equivalent to that of steam power.

Animal power might be employed to advantage in the conveyance of burdens upward on inclined planes of almost any acclivity, by means of stationary gins or oth-

Machinery, especially in cases where there is not a sufficient amount of business done upon the road to justify the expense of a Stationary Steam Power, and where the difficulties of supplying a Steam Engine with fuel and water would render doubtful the economy of its construction and use.

The relative advantages of Animal and Steam power, may be inferred from the following considerations, viz: the efficiency of the latter is inversely as the distance through which it operates, whereas that of the former is inversely, in the compound ratio of the velocity and distance, or, in other words, the intensity of Steam Power is inversely as the velocity and the intensity of Animal power is inversely as the squares of the velocity. Hence the conclusion already advanced that the advantages resulting from the application of these two descriptions of power, may be regarded as equal, when a moderate speed only is required, and when a rapid speed is produced by means of Stationary Machinery, but in cases where greater speed is required and the power must participate in the locomotion of its load, Steam power

is entitled to a decided preference, its relative efficiency increasing at every accelleration of speed.

In regard to the employment of Stationary Steam Power, it is not deemed essential, that coal should always be at hand, or that supplies of this article should be procured at a cheap rate. If wood can be procured at the rate of $1,50 or $2 per cord, it may be advantageously substituted for coal, in almost any situation where the latter must be procured at the expense of transportation from a distance of 15 or 20 miles. Coal however, seems to be the only fuel hitherto employed in connexion with Locomotive Engines, and is undoubtedly better adapted to the purposes of locomotive power, than any other fuel, on account of its compactness, and the convenience with which it may be transported.

With respect to the locomotive power contemplated for the B. & O. R. R., Animal power alone is intended to be used, except at the Inclined planes at Parr Spring Ridge, until the completion of that portion of the road situated between Baltimore and the Valley of the Potomac ; subsequently to which steam power will probably be introduced should the exigencies of the business upon the road require it. Even at the Inclined Planes just mentioned, it will not be advisable to erect a Steam Engine till the amount of travel and transportation upon the road, shall be sufficient to keep it in operation.

In conclusion I beg leave to observe that the foregoing remarks have been hastily thrown together, and to offer as an apology for the numerous incoherencies and defects that have been committed therein, my want of sufficient leisure to revise and amend them.

Various other details might have been given, bearing directly upon the subjects proposed by his Excellency,

but for the reason just mentioned they have been unavoidably withheld. In order to supply in some small measure these deficiencies, I take the liberty to refer to the letter I had the honour to address to you, under date of March 1827. To the several Reports made by the Board of Engineers to the President and Directors of the B. & O. R. R. Co. and to the Rail Road Manual, which I had the honour to inscribe to the Board of Directors of the same Company.

I have the honour to be, Sir, very

respectfully your most obt. servt.

S. H. LONG,

Bt. Lt. Col. Prest. Bd. of Engineers.

Balt. Dec. 1*st.* 1829.

P. E. THOMAS, ESQ. *Prest. B. & O. R. R. Co.*

DESCRIPTION

Of the Performance of three Locomotive Engines on the Liverpool and Manchester Rail Road.

From the London Mechanics' Magazine.

The great Rail Road between Liverpool and Manchester being now nearly completed, the directors of the undertaking sometime ago announced that they would give a premium of £500 for the Locomotive Engine which should at a public trial, to be made on the first of the present month of October, (afterwards postponed to the 6th,) draw on the rail-way a given weight, with the greatest speed, at the least expense.

The principal conditions on which the prize was offered, were these,—first, that each Engine offered for the competition should weigh not more than six tons, and be capable of drawing after it, day by day on a level plain, a train of carriages of a gross weight equal to three times the weight of the engine itself, at a rate of not less than ten miles per hour, with a pressure of steam in the boiler not exceeding 50 lbs. on the square inch. Second, that the Engine and boiler should be supported on springs, and rest on six wheels, and the height from the ground to the top of the chimney should not exceed 15 feet. Third, that the Engine should "effectually consume its own smoke;" and fourth, that there should be two safety valves, one of which should be completely out of the reach of the engine-man's interference.

The gentlemen appointed by the Directors to act as

Judges on the occasion, were J. U. Rastrick, Esq. of Stonebridge, Civil Engineer, Nicholas Wood, Esq. of Killingsworth, Civil Engineer, (author of the excellent work on Railways,) and John Kennedy, Esq. of Manchester. The portion of the rail-way chosen for the "running ground" was on the Manchester side of Rainhill Bridge, (about nine miles from Liverpool,) where the rail-way runs for two or three miles on a dead level.

Early on Tuesday, the day of competition, great crowds of people were assembled from all parts to witness the sight. There were many individuals who had come hundreds of miles for no other purpose, and as may readily be supposed, these were not idle spectacle hunters, but chiefly engineers and men of science, capable of appreciating in its full extent the great importance of the exhibition.

The Engine which made the first trial was the "Rocket" of Mr. Robert Stephenson, (the son, we believe, of Mr. George Stephenson, the engineer of the railways.) It is a large and strongly built engine, and went with a velocity, which as long as the Spectators had nothing to contrast it with, they thought it surprising enough. It drew a weight of twelve tons, nine cwt. at the rate of ten miles four chains in an hour, (just exceeding the stipulated maximum,) and when the weight was detached from it, went at a speed of about Eighteen miles an hour. The faults most perceptible in this engine, were a great inequality in its velocity, and a very partial fulfilment of the condition that it should "effectually consume its own smoke."

The next engine that exhibited its powers, was the "Novelty" of Messrs. Braithwaite and Erickson. The great lightness of this Engine, (it is about one half lighter

than Mr. Stephenson's) its compactness, and its beautiful workmanship excited universal admiration; a sentiment speedily changed into perfect wonder by its truly marvellous performances. It was resolved to try first its speed merely; that is at what rate it would go carrying only its compliment of coke and water with Messrs. Braithwaite and Erickson to manage it. Almost at once it darted off at the amazing velocity of twenty-eight miles an hour, and it actually did one mile in the incredibly short space of one minute and fifty-three seconds Neither did we observe any appreciable falling off in the rate of speed; it was uniform, steady and continuous. Had the rail-way been completed, the engine would at this rate have gone nearly the whole way from Liverpool to Manchester within the hour; and Mr. Braithwaite has indeed publicly offered to stake a thousand pounds, that as soon as the road is opened, he will perform the entire distance in that time.

It was now proposed to make a trial of the "Novelty," with three times its weight attached to it, but through some inattention as to the supply of water and coke, a great delay took place in preparing it for its second trip, and by the time all was ready, the day was drawing so near to a close, that the directors thought it proper to defer the prosecution of the competition till the following day.

Second Day, 7th October.—The "Novelty" engine of Messrs. Braithwaite & Erickson was this day tried with a load of three times its weight attached to it, or eleven tons, five cwt., and it drew this with ease at the rate of 20¾ miles per hour, thus proving itself to be equally good for speed as for power. We took particular notice to-day of its power of consuming its own smoke,

and did not any time observe the emission of the smallest particle from the chimney. The weather now became wet, and the railways clogged with mud, which made it necessary to suspend the prosecution of the experiments before the day had half elapsed. The attendance of spectators this morning was by no means so numerous as on the preceding day; but there were but few of those absent, the engineers, men of science, &c. whose presence was most desirable.

Third Day, 8th October.—Before the commencement of the experiments to-day, it was announced that the Judges, on reconsidering the card of "Stipulations and Conditions," originally issued, and of which we gave the substance last week, had considered them so defective as to make it necessary to substitute the following:

TRIAL OF THE LOCOMOTIVE ENGINES.

Liverpool and Manchester Railway.

"The following is the ordeal which we have decided each locomotive engine shall undergo in contending for the premium for £500 at Rainhill:

"The weight of the locomotive engine, with its full complement of water in the boiler, shall be ascertained at the weighing machine by eight o'clock in the morning, and the load assigned to it shall be three times the weight thereof.

"The water in the boiler shall be cold, and there shall be no fuel in the fire-place. As much fuel shall be weighed, and as much water shall be measured and delivered into the tender carriage, as the owner of the engine may consider sufficient for the supply of the engine for a journey of thirty-five miles; the fire in the

boiler shall then be lighted, and the quantity of fuel consumed for getting up the steam shall be determined, and the time noted.

"The tender carriage, with the fuel and water, shall be considered to be, and taken as a part of the load assigned to the engine.

"Those engines that carry their own fuel and water, shall be allowed a proportionate deduction from their load, according to the weight of the engine.

"The engine, with the carriages attached to it, shall be run by hand up to the starting post, and as soon as the steam is got up to fifty pounds per square inch, the engine shall set out upon its journey.

"The distance the engine shall perform each trip, shall be one mile and three quarters each way, including one eighth of a mile at each end, for getting up the speed, and for stopping the train; by this means the engine with its load will travel one and a half mile each way at full speed.

"The engine shall make ten trips, which will be equal to a journey of thirty-five miles, thirty miles whereof shall be performed at full speed, and the average rate of travelling shall not be less than ten miles per hour.

"As soon as the engine has performed this task, (which will be equal to the travelling from Liverpool to Manchester,) there shall be a fresh supply of fuel and water delivered to her, and as soon as she can be got ready to set out again, she shall go up to the starting post and make ten trips more, which will be equal to the journey from Manchester back again to Liverpool.

"The time of performing every trip shall be accurately noted, as well as the time occupied in getting ready to set out on the second journey.

" Should the engine not be enabled to take along with it sufficient fuel and water for the journey of ten trips, the time occupied in taking in a fresh supply of fuel and water shall be considered and taken as a part of the time in performing the journey.

(Signed) J. U. RASTRICK,
Stonebridge, C. E.
NICHOLAS WOOD, Esq.
Killingsworth, C. E.
JOHN KENNEDY, Esq.
Manchester,
Judges.

Liverpool, October 6, 1829.

The Engine which exhibited on this the third day was, " The Rocket" of Mr. Stephenson. The trial was conducted in the manner laid down in the " Ordeal " we have just quoted ; and it was understood on all hands that this trial should be considered decisive of its merits.

The engine with its complement of water in the boiler, weighed 4 tons 5 cwt. and the load attached to it was 12 tons 15 cwt. or, including a few persons who rode, about 13 tons. The journey was about 1½ mile each way with an additional length of 220 yards at each end to stop the engine in, making in one journey 3½ miles— the first experiment was for 35 miles, which is exactly 10 journeys, and including all the stoppages at the end was performed in 3 hours and 10 minutes, being upwards of 11 miles an hour. After this a fresh supply of water was taken in, which occupied 16 minutes, when

the engine again started and ran 35 miles in 2 hours and 52 minutes, which is upwards of 12 miles an hour including all stoppages. The speed of the engine with its load, when in full motion, was at different times 13, 13½, 14 and 16 miles an hour, and had the whole distance been in one continued direction, there is little doubt but the result would have been 15 miles an hour. The consumption of coke was on an average about half a ton in the 70 miles.

Fourth day 9th October.—To day a public notice appeared from Messrs. Braithwaite and Erickson, stating that in consequence of the alterations made in the conditions of the competition, the trial of their engine in the manner prescribed by the new "Ordeal" had with the approbation of the judges been deferred till the following day. The 9th became thus a *dies non* in the competition.

Fifth day 10th October.—At the appointed hour this morning the "Novelty" was weighed, and three times its weight assigned to it by the Judges. The steam was got up in 54 minutes from the time of lighting the fire. The engine then went one trip by way of rehearsal, when a small pipe accidentally gave way, and it was found necessary to send to Prescott a distance of two miles to have it repaired. In the interval Mr. Stephenson's locomotive engine was run twice down the course and back making in all 7 miles, but with the whole load taken off from behind, including even the tender-carriage with the water-tank and fuel. Thus stripped for the race the "Rocket" performed the 7 miles in the space of 14 minutes 14 seconds, being at the rate of 30 miles an hour. This was a rate of speed nearly equal to the utmost which the "Novelty" had achieved, but as

it carried with it neither fuel nor water, it is not a speed which it could have long sustained.

The "Novelty" having now had its broken pipe repaired, made several trips, but solely for the gratification of the spectators, who were to day extremely numerous, and not with any view to a decisive exhibition of its powers.

Mr. Vignoles the engineer who rode on the engine and timed it, during two of these trips, has favoured us with the following statement of its performances.

The total weight of the engine and load was 10 tons 6 cwt. 1 qr. The engine was brought up near the starting post a few minutes before three o'clock, and the rate of its speed, loaded as above detailed is recorded in the following tables, in which the time indicates the moment of her passing each post.

The distance between posts 1 and 2, and between posts 8 and 9, is only one furlong (220 yards) being the space allowed to acquire and check the engine's velocity, after and previous to turning; the distance between all the other posts is precisely a quarter of a mile (440 yards.)

Eastward Trip.

H.	M.	S.			Strokes per min
2	59	10	starting post . .	1	
2	59	51	judges tent . .	2	120
3	0	50	bridge mark . .	3	
3	1	36	grand-stand post .	4	140
3	2	22	quarter post . .	5	
3	3	5	quarter post . .	6	140
3	3	47	10 mile post . .	7	
3	4	30	judges post . .	8	142
3	4	57	turning post . .	9	

Pressure always under 50 lbs. per square inch.

The engine went off from the starting post at the rate of 12 miles an hour and her velocity rapidly increased during the whole trip.

By the above tables it will be seen that the distance between the 9 and 10 mile marks was performed in 3 minutes and 7 seconds, and the mile between the quarter post near the grand stand and the judges' tent at the eastern end of the course, was run in 2 minutes and 54 seconds, while the last half mile was performed in 85 seconds, being at the rate of $21\frac{1}{6}$ miles per hour. The whole time between the tents of the Judges at each end, being exactly $1\frac{1}{2}$ mile, was performed in 4 minutes and 39 seconds, being at the rate of $17\frac{1}{2}$ miles per hour.

The gentleman at the brake of the wheel not being sufficiently experienced, the engine was not checked so soon as it ought to have been on the return, and went beyond the level part of the road, not being stopped until it had got some yards down the eastern inclined plane; upwards of $2\frac{1}{2}$ minutes were lost in consequence.

On returning, the following was the record of the

Westward Trip.

H.	M.	S.			Strokes per min.
3	8	7	starting post . .	9	
3	8	49	judges tent . .	8	110
3	9	50	10 mile post . .	7	
3	10	49	quarter post . .	6	110
3	11	49	quarter post . .	5	
3	12	49	grand-stand post .	4	110
3	13	47	bridge mark . .	3	
3	14	43	judges tent . .	2	110
3	15	28	starting post . .	1	

Pressure always under 50 lbs. per square inch.

The following calculation, founded on the preceding results, was made by Mr. Vignoles and Mr. Price of Neath Abbey :—

The maximum number of strokes was 142 per minute, while 440 yards were traversed in 43 seconds. Diameter of wheels 50.1 inches—circumfercnce 157.4 inches 157.4 X 142. equal to 621 yards, being the velocity per minute of the circumference of wheel, or 21 miles and 300 yards per hour. Then as 60 seconds : 621 yards : : 43 seconds : 445 yards.

Thus the calculated distance of the run (considering the wheel as a perambulator) agrees within 5 yards with the space actually passed over; and this difference might arise from the most trifling inaccuracy of noting the time—a quarter of a second at each end being sufficient to produce this decrepancy; so that it may fairly be concluded, that there was no slipping of the wheels at a velocity of nearly 22 miles an hour with a load.

Another carriage, with seats for the accommodation of passengers, was now substituted for the loaded waggons attached to the "Novelty," and about forty-five ladies and gentlemen ascended to enjoy the great novelty of a ride by steam. We can say for ourselves that we never enjoyed any thing in the way of travelling more. We flew along at the rate of a mile and a half in three minutes; and though the velocity was such, that we could scarcely distinguish objects as we passed by them, the motion was so steady and equable, that we could manage not only to read, but write.

Sixth day, 13th October. Mr. Acworth's engine. The "Sans Pareil" was pronounced to be this day ready to exhibit its powers. We were informed that, on weighing it, the judges found it to exceed by two or

three hundred weight the maximum of six tons; it was nevertheless allowed to start to do 70 miles in the same manner as "the Rocket" with three times its great weight attached to it, that is, upwards of 18 tons. It was soon manifest that a very powerful competitor had entered the field.

For two hours "the Sans Pareil" kept going with great regularity and during that time completed upwards of 25 miles. It went occasionally when at its utmost speed, a mile in 4′ 10″ and 4′ 17″ being at the rate of nearly 15 miles an hour. While thus bidding fair, if not to win the prize, at least to come in second best, a similar accident happened to it as befel "the Novelty," one of the feed pipes burst, and it was rendered for the time incapable of proceeding.

We understand the judges subsequently resolved that "the Sans Pareil" should have another trial on Friday, the 16th.

Seventh day, 14th October. It being generally understood that this was to be the day of a more decisive trial of Messrs. Braithwaite and Erickson's engine—that is, according to the new conditions named by the judges—there was almost as numerous an assemblage of spectators as on the first day of the competition.

A fresh pipe had, it appeared, been substituted for the one which failed on the preceding trial; one or two other parts of the machinery that were in a faulty state, had also been renovated; but the engine with the exception of some of the flanges of the boiler being, as Mr. Erickson expressed it, rather green, was pronounced in a working state. The load assigned to it by the judges was 6 tons 2 cwt.

The steam was on this occasion got up to a pressure

of 50 lbs. in somewhat less than 40 minutes, and at an expenditure of about 15 lbs. of Coke. The engine now started to do the 70 miles for a continuance; but just as it had completed its second trip of three miles, when it was working at the rate of 15 miles an hour, the new cement of some of the flanges of the boiler, yielded to the high temperature to which it was exposed, and the spectators had again the mortification to hear it announced that it was under these circumstances impossible the trial could go on.

We were informed that early on Wednesday morning before we reached the course, an experiment had been made with Mr. Stephenson's engine on a part of the Rail-way which runs with an inclination of 1 in 96, [55 feet per mile] and that it drew up this plane a carriage containing 25 passengers, with great ease.

[The Novelty was subsequently withdrawn from further competition, and the Sans Pareil was excluded by being heavier than the prescribed weight. The premium was awarded to the Rocket.]

We now proceed to compare the rate of speed accomplished by the different engines. "The Novelty" went on the second day of the competition with three times its weight attached to it $20\frac{3}{4}$ miles in one hour. The total weight moved, including the carriage, was about 15 tons.

In calculating the weight in this instance no deduction was made on account of the engine's carrying its own water and fuel, but when prepared for its intended trials on the subsequent days of the competition, due allowance was made for this circumstance. The load then assigned to it by the judges was 6 tons, 2 cwt. When

it accomplished the trips recorded by Mr. Vignoles, (p. 138) the total weight moved, including that of a number of persons on the engine and waggons, was only 10 tons 6 cwt. 1 qr.; and the speed which it then realized was nearly equal to 22 miles an hour. It will be observed, that though some increase of velocity was thus acquired, it was by no means proportional to the reduction of the weight; a circumstance which is doubtless to be ascribed to the very imperfect working order in which the engine was at the time of this second trial. When the weight drawn was reduced to merely that of a waggon containing 45 persons, equal to about 3½ tons, and the total weight moved to about 9 tons, the velocity was increased to 30 and 32 miles per hour; a rate though unprecedently great, is still less than what the previous performances of this engine with double that weight might have warranted us to expect from it.

The total weight moved by "the Rocket" when it went the 70 miles continuously was 17 tons; and the greatest number of miles which it traversed in any one hour was 12½ miles. Stripped of all weight and carrying just as much material as would suffice for a couple of trips of a mile and a half each, it went at the rate of 30 miles an hour.

Drawing a carriage loaded with passengers it went at a velocity which sometimes reached 24 miles an hour. The weight drawn by "The Sans Pareil" if calculated in the same way as that assigned to "the Rocket," must have been 13 tons 6 cwt. (and not 18 tons, as stated in our account of the sixth days proceedings) the total weight moved, 17 tons 14 cwt. The greatest

speed which it accomplished in one hour was 12½ miles.*

The comparative speed of the three engines as verified by the recent experiments, stands therefore as follows:

	MILES PER HOUR.	
	With a load equivalent to three times the weight of the engine.	With a Carriage and Passengers.
"The Sans Pareil" . . .	12½	
"The Rocket"	12½	24
"The Novelty"	20¾	32

Experiments on the Baltimore and Ohio Rail Road.

From the Baltimore American, of Dec. 29, 1829.

Quite a lively and animated scene was exhibited yesterday along the line of the rail-road which is laid down between the Company's lot on Pratt-street, and the Carrolton Viaduct, [one and a half miles.] Although no public notice had been given, a large number of citizens and strangers assembled on the ground for the purpose of witnessing the trial of passenger carriages, which it was understood would take place at 11 o'clock. Accordingly, about that hour a single horse was attached to two of the Winan's carriages, containing forty-one persons, among whom we noticed Judge Smith, member of the U. S. Senate from South Carolina, and the following members of the House of Representatives: Messrs. Creighton and Irwint of Ohio, Ford of Pennsylvania, Sprigg and Howard of Maryland, Kendall of

* The cost of fuel consumed in the experiments is estimated as follows, viz. by the Sans Pareil 2d. per mile, the Rocket 3 half pence, and the Novelty 1 farthing—the fuel used being coke reckoned at 20s. per ton.

Massachusetts, White of N. York, and young of Connecticut; and Messrs. Reese and Dennis of the Maryland Senate. With this load the horse moved forward with great ease and rapidity to the Viaduct and back again, the rate of speed being from ten to eleven miles an hour.

An entirely new carriage, on the same principle, but more elegantly finished, was now brought forward; it was filled by twenty-five persons, two-thirds of whom were ladies. The road wheels of this carriage were of greater diameter than the others, and its movements appeared to us to be more easy and efficacious on that account. A single horse drew this carriage and its load to the end of the road and back, in a brisk trot, with very slight exertion. A second trip was afterwards made by the same carriage and horse, with another load of twenty-five persons, at the rapid rate of twelve miles an hour. The coupled carriages were also started a second time, with a load of fifty-five persons, and a single horse attached, and performed the distance at the rate of about nine miles an hour. The last experiment, which took place after we left the ground, was made by attaching the three carriages to each other, and a single horse to the whole. The aggregate number of persons in these carriages was eighty-four, and yet with this extraordinary number, we learn that the animal performed the trip with the same ease and velocity. We omitted to state, that early in the day, a carriage of light construction, on the Winan's principle, was tried. It was fitted with a winch, for the purpose of being propelled by persons seated in front of it. In this way, the vehicle, with seven persons in it, was rapidly propelled by two; but owing to the breaking of the crank, the trial

was suspended. We are informed, that later in the day, two dogs were attached to this car, and easily drew the six persons who were seated in it. Although the Macadamized horse-path was quite new, and in an unfavourable state for use, the experiments were nevertheless of a highly gratifying character, and afforded to all who were present the most conclusive evidences of the superior advantages which a rail-road offers for the transportation of passengers and merchandize.

From the Baltimore American, of Jan. 2d.

We have, on several late occasions, taken notice of the novel and highly satisfactory experiments which have been made on that part of the Baltimore and Ohio Rail-Road laid down between Pratt Street and Carrolton Viaduct. Notwithstanding the limited extent of this experimental line, the road appears to attract fresh crowds of visiters every day the weather will permit, all of whom, whether citizens or strangers, come away highly gratified. The weather yesterday being remarkably mild and pleasant, vast numbers availed themselves of the opportunity to examine the road and viaduct, and to enjoy the gratification of a ride in the Winan's carriages. The Hon. the Postmaster General having reached this city the evening before, and being desirous of visiting the road, he was accordingly accompanied thither yesterday by the gentlemen attached to the board of direction. A carriage having been brought out, the party, consisting of twenty-four ladies and gentlemen, including the Postmaster General, were drawn to the viaduct by one horse, in actually a little less than six minutes. After alighting to view the magnificent granite structure, of which a minute description was published in last week's Ameri-

can, the party again seated themselves, and were conveyed back to Pratt Street in the same brief period, or at the extraordinary rate of fifteen miles an hour. In order to show the perfect ease and rapidity with which heavy loads can be transported on a well constructed rail-road, three carriages were attached to each other, and being filled with more than eighty persons, were readily drawn by one horse, at the rate of upwards of eight miles an hour. Averaging each passenger at one hundred and fifty pounds weight, and estimating the three carriages to weigh together two and a half tons, it follows that a single horse has actually drawn a load of at least eight and a half tons, at the speed of upwards of eight miles an hour; and this extraordinary result was accomplished without any apparent distress to the animal, or indeed uncommon exertion on his part.

From the Baltimore Patriot of January 7, 1830.

Yesterday by invitation of the President and Directors, at 12 o'clock the Mayor of the City, and the members of both Branches of the City Council, with other gentlemen, assembled upon the ground. The company, forty-two in number, were placed in two cars connected together, and a swift trotting horse took them easily to the Carrolton Viaduct in eight minutes, and returned in less than 7½ minutes, being at the rate of about thirteen miles an hour.